Informational Leaflet 102

1966 BRISTOL BAY RED SALMON SMOLT STUDIES

A summary of data collected from red salmon (Oncorhynchus nerka) smolt programs on the Kvichak, Wood and Naknek Rivers

Edited By:

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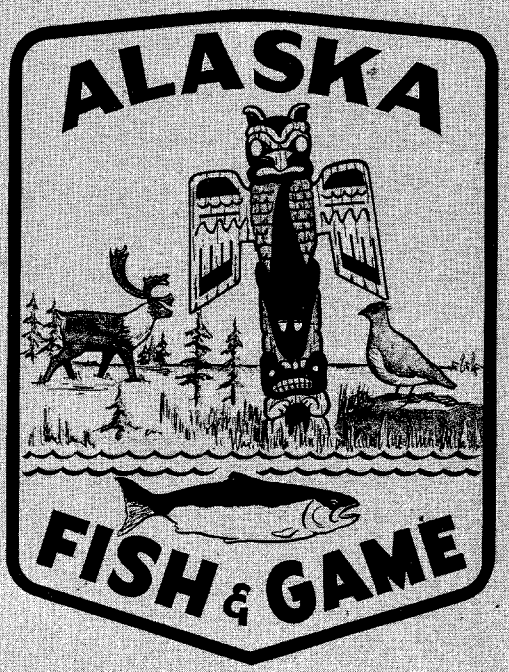

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1966 BRISTOL BAY RED SALMON SMOLT STUDIES

A summary of data collected from red salmon (Oncorhynchus nerka) smolt programs on the Kvichak, Wood and Naknek Rivers

The first section of this report on the Kvichak River Smolt Studies by Donald M. Stewart was financed by the Commercial Fisheries Research and Development Act (P.L. 88-309) under sub-project 5-5-R-2, Contract No. 14-17-0007-536.

FOREWORD

The Alaska Department of Fish and Game, Division of Commercial Fisheries has decided to incorporate all Bristol Bay red salmon smolt studies into one Informational Leaflet this year, rather than expend unnecessary time, money and effort publishing each study as a unit. Also, much repetitious material will be avoided.

This leaflet is presented as a data report rather than a methods and procedural document. For those wishing a detailed account of methods and procedures we suggest they review Informational Leaflets concerning smolt studies, published prior to this work.

In an attempt to achieve brevity and continuity, most of the annual comparative data is presented in appendix form. Only those tables and figures pertinent to this year's studies will be found in the main content.

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1966 KVICHAK RIVER RED SALMON (Oncorhynchus nerka) SMOLT STUDIES

By

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I. INTRODUCTION

The Kvichak River smolt index project is designed to provide an index of the relative annual abundance of red salmon (Oncorhynchus nerka) smolt leaving Lake Iliamna and migrating down the Kvichak River to the Bering Sea. This project was initiated in 1955. The index obtained has been used to predict adult red salmon returns to the Kvichak and to evaluate production from various levels of escapement. Data on age, length and weight of smolt has also been collected.

Although much valuable information on red salmon population dynamics in the Kvichak has been collected, the index project is not accurately assessing smolt production in this system. This is evidenced by the variability in the accuracy of predictions of returning run size based on these smolt indices and certain obvious defects in the index sampling.

One of the most obvious defects in the index sampling is that it is based on the assumption that an equal proportion of the smolt population is sampled annually. Presently, a single fyke net samples approximately 0.01 of the river's width in an area with two channels, an uneven bottom profile, and a tremendous variation in water color, size of migration and size of fish from year to year. Additionally, at the present site ice flows often interfere with the fishing of the net for periods of up to a week and commonly for a day at a time.

The value of obtaining an accurate measure of the smolt outmigration in the Kvichak to both the prediction and an understanding of the cycle mechanics of this system is apparent. Accordingly, a program was drawn up and approved for Federal funding under PL 88-309 to obtain an estimate of the total smolt outmigration in the Kvichak. Part of this program consisted of the continuation of the index net fishing for comparative purposes, at least during the early years of the project.

II. CONTINUATION OF INDEX PROJECT

A. Methods and Procedures

From May 18 to June 16, the standard index fyke net was fished in the Kvichak River in the same location and manner as it has been since 1955. Fishing was conducted on a sampling basis from May 18 to June 3 since no smolt outmigration was evident. During the period June 4 through June 16, the net was fished twenty-four hours per day except when ice flow forced removal of the net from the river.

B. Results and Discussion

1. Ice Interference, Climatical and Hydrological Data

Ice interference from the Lake Iliamna breakup was especially severe in 1966. Not only were there many days when the ice completely choked the river precluding any type of fishing, but the main peak of the outmigration occurred during a period of heavy ice flow. Figure 1 shows dates of recorded heavy ice flow in the Kvichak and the peak dates of outmigration for the years 1956-1966. 1961, 1963, 1964 and 1966 experienced the worst flows coincidental with the peak of the smolt outmigration. In the early years of the project little or no ice interference was recorded. Figure 2 further illustrates the ice interference problem in 1966 by showing the hours of fishing time missed per day at the index site and further down river at the outmigration site.

Table 1 gives the climatological and hydrological data collected in 1966.

It has been shown in past years that substantial outmigration did not commence when water temperatures were under 36° F. However, 36° F. should not be construed as the triggering mechanism, i.e., the temperature that triggers outmigration.

In 1966, water temperatures reached 41° F. in May, but the outmigration did not commence until June 4, when the water temperature readings were 38° F. in the a.m. and 34° F. in the p.m. On June 5, substantial numbers of fish were observed, but the two water temperature readings were only 35° and 33° F. Actually, all through the outmigration water temperatures hovered at or near 36° F. This reduction in water temperature (and the severe ice conditions), was undoubtedly due to the consistently northerly winds experienced in late May and early June, which held the Iliamna ice pack against the west shore of the lake and the outlet until it dissipated--much of it running down the river.

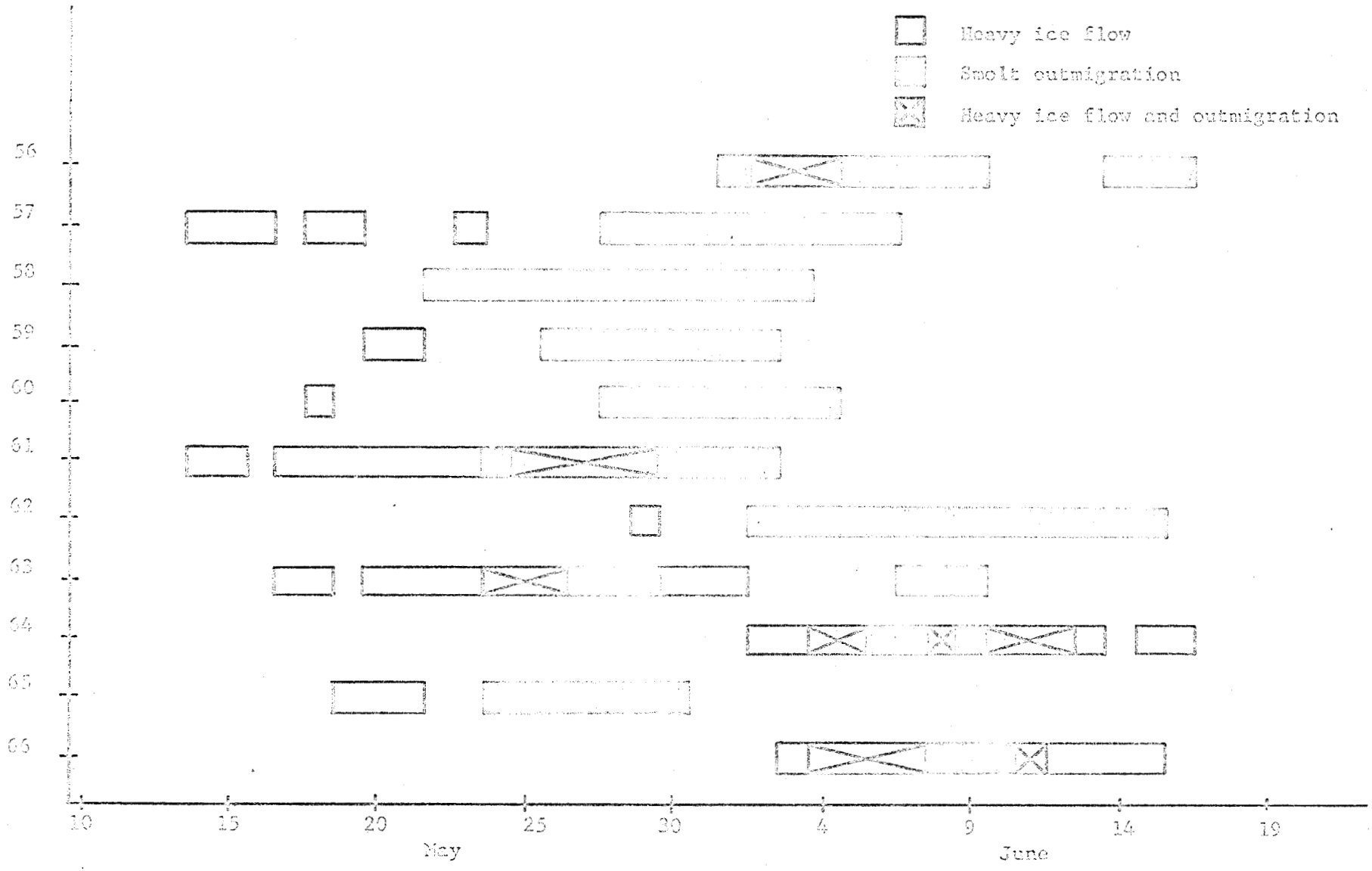

Figure 1. The above chart depicts dates of heavy ice flow, outmigration of smolt and dates when ice flow and outmigrating smolt coincided on the Kvichak River, 1956-1966.

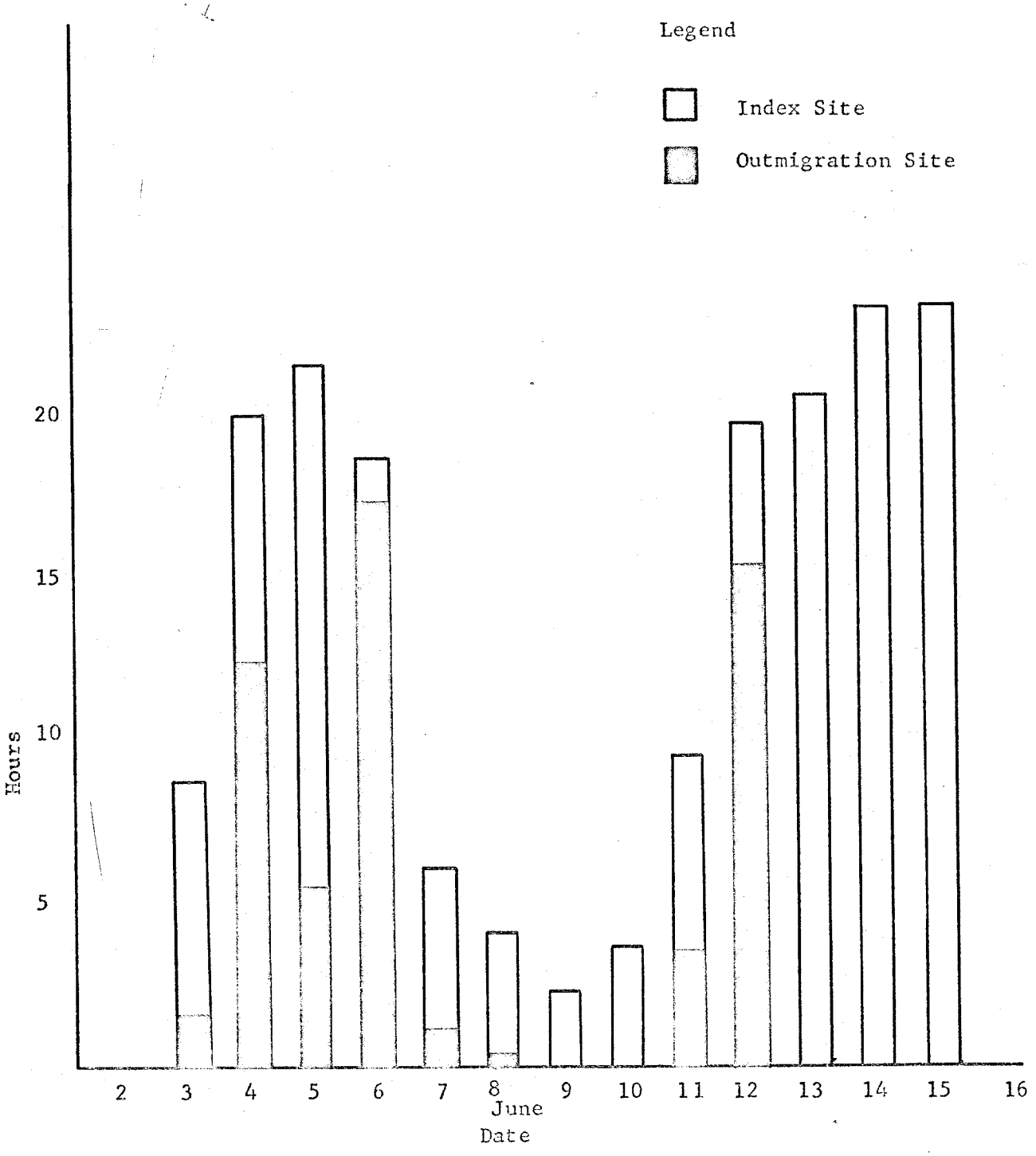

Figure 2. Fishing time missed due to ice flow on the Kvichak River red salmon smolt project, 1966 1/

1/ Outmigration site closed on June 13, 1966

Table 1. Climatological and Stream Observations - Kvichak River 1966, May 16-June 26

Date	Sky 9 am	Sky 8 pm	Precip.-24 Hr. 9 am	Precip.-24 Hr. 8 pm	Precip.-24 Hr. Amt.	Wind Dir.-Vel. 9 am	Wind Dir.-Vel. 8 pm	Air Temp. °F 8 pm max	Air Temp. °F 8 pm min	Water Temp. °F 9 am	Water Temp. °F 8 pm	Water Gauge 8 pm	9 am Turbidity	Remarks
5/16	4	1	-	-	-	N 15	N 5		-	38	34	18.50[1]/	A	
17	1	3	-	-	-	SW 8	S 6		-	38	38	18.75	A	Max-Min Broken
18	4	4	0.11	0.25	0.36	N 13	S 8		-	38	38	19.75	A	New Max-Min.
19	4	4	0.12	0.17	0.29	SW 12	SW 10	49	36	38	39	20.00	A	Rain-Ice moving down.
20	3	2	0.01	0.04	0.05	NE 12	SW 10	45	39	40	40	19.50	A	
21	4	1	-	0.02	-	-	SW 12	37	31	-	38	20.00	A	
22	4	4	0.01	0.04	0.05	NW 15	NW 7	30	29	38	37	19.50	A	
23	4	3	0.00	0.00	0.00	NW 10	S 4	39	30	38	38	19.75	A	
24	1	2	0.00	0.00	0.00	S 8	S 20	42	29	41	39	19.50	A	
25	4	4	0.00	0.00	0.00	S 20	S 27	38	33	38	38	19.75	A	
26	4	4	0.01	0.10	0.11	S 5	N 2	-	-	38	38	20.50	A	Max-Min out of order
27	3	4	0.01	0.00	0.01	NW 6	E 3	-	-	39	38	20.00	A	
28	3	2	0.00	0.00	0.00	N 8	W 3	-	-	37	37	20.25	A	Heavy ice all day
29	3	4	0.00	0.00	0.00	W 8	0	31	46	38	38	16.00	A	Ice flow increasing
30	4	4	0.22	0.01	0.23	NE 10	NE 17	42	42	36	36	-	A	Ice took out H_2O gauge
31	4	4	0.05	0.20	0.25	NE 7	NE 8	48	28	37	38	-	A	Heavy ice all day
6/ 1	3	4	0.04	0.03	0.07	N 10	N 3	50	27	38	38	-	B	
2	3	1	0.10	0.00	0.10	N 8	NW 7	61	-	38	38	-	B	Ice moderate
3	2	4	0.00	0.00	0.00	N 14	NW 10	61	25	40	34	-	A	No ice AM-heavy ice PM
4	3	3	0.00	0.00	0.00	N 8	NW 5	44	34	38	34	-	A	AM ice-PM heavy ice
5	3	2	0.01	0.00	0.01	NW 8	NE 8	64	41	35	33	20[2]/	B	H_2O gauge reset-ice took out PM
6	1	3	0.00	0.01	0.01	NW 14	NE 5	64	34	36	34	-	A	Ice flow heavy
7	1	4	0.01	0.03	0.04	NW 11	NW 15	48	36	36	36	-	A	Ice flow light
8	3	4	0.01	0.00	0.01	NW 18	N 15	59	32	36	36	-	A	Light ice flow AM
9	3	3	0.00	0.00	0.00	NE 14	NE 5	66	42	37	36	-	A	Light ice flow AM

Codings:

Sky

0. No observation made
1. Clear sky, cloud cover not more than 1/10
2. Cloud cover not more than 1/2 sky.
3. Cloud cover more than 1/2 sky.
4. Complete overcast
5. Fog or thick haze

Turbidity

A. Clear
B. Partly Cloudy
C. Cloudy
D. Debris

1/ Water gauge set at 18" 0930 5/16/66 water level 7.44' below bench mark

2/ Water gauge set at 20" 0900 6/5/66 water level 6.55' below bench mark.

Table 1. Climatological and Stream Observations - Kvichak River 1966 - May 16 - June 26 (cont.)

Date	Sky 9 am	Sky 8 pm	Precip.-24 hr. 9 am	Precip.-24 hr. 8 pm	Precip.-24 hr. Amt.	Wind Dir. 9 am	Wind Dir. 8 pm	Wind Vel. 9 am	Wind Vel. 8 pm	Air Temp. °F 8 pm max-min	Water Temp. °F 9 am	Water Temp. °F 8 pm	Water Gauge 8 pm	Turbidity 9 am	Remarks
6/10	3	-	0.01	-	0.01	NW 8	-	-	-	38	-	-	A	Ice flow light	
11	3	4	0.00	0.00	0.00	N 10	NW 13	60	38	40	32	-	A	Ice flow heavy	
12	2	3	0.00	0.00	0.00	NE 12	NE 10	66	42	36	34	-	A	Ice flow heavy	
13	4	3	0.00	0.00	0.00	NE 7	NE -	62	41	44	41	-	A	Ice flow heavy	
14	4	3	0.09	0.22	0.31	NE 5	NE -	60	42	36	34	-	B	Ice flow heavy	
15	3	3	0.00	0.00	0.00	NE 10	NE 10	50	37	36	40	-	A	Ice flow heavy	
16	2	4	0.00	0.01	0.01	NE 7	NE 3	52	75	42	44	-	A	Ice flow light	
17	4	3	0.11	0.02	0.13	NE 5	NE 13	62	42	43	45	-	A	Ice flow light	
18	4	3	0.06	0.05	0.11	N 5	NW 5	48	42	45	46	-	C		
19	2	1	0.02	0.00	0.02	SW 12	SW 5	72	46	49	50	-	C		
20	1	1	0.00	0.00	0.00	S 12	N 5	74	40	50	50	-	A		
21	1	4	0.00	0.08	0.08	N 3	N 2	72	50	52	50	-	A	Rain	
22	4	1	0.01	0.00	0.01	0	N 3	72	43	50	50	-	B		
23	3	2	0.02	0.00	0.02	SW 10	NE 7	68	36	50	50	-	B	Wind Gusting to 13	
24	1	2	0.00	0.00	0.00	N 6	NE 3	68	43	51	51	-	B		
25	1	1	0.00	0.00	0.00	N 15	NE 6	60	40	51	52	-	A		
26	4	4	0.00	0.01	0.01	S 22	NE 8	65	51	51	50	-	A		

Examination of weather and ice data from past years indicates that in all years where heavy ice conditions were encountered, the commencement of the outmigration was either coincidental with or after the occurrence of heavy ice in the river. In 1966, substantial numbers of smolt were observed on two occasions during the day and in the late evening, migrating out under extremely heavy ice flow. There is no reason to suspect that this did not occur at night also, but visibility prevented any observation of this. In some years, the smolt outmigration has commenced at a considerable time after the ice has passed downriver, but at no time before. Thus, it appears that smolt outmigration is linked to breakup of the Iliamna ice pack, which is in turn, undoubtedly, linked to lake temperature and, less directly, to river temperature.

2. Index Catch

Table 2 gives the index net catches. No smolt were observed migrating prior to June 4. At 1500 June 3, ice started flowing bank to bank and flowed continuously until 0900 June 6. At 1216 June 4, the index net was again put in the water and smolt started entering it immediately. It was fished until 1527 when bank to bank ice again forced its removal. During this three hours and eleven minutes the highest catches of any afternoon period of the season were recorded. There is some evidence that few smolt passed the index site on June 3, or the morning of June 4. Very little predatory bird activity was observed during this time and smolt did not appear in numbers at Otter Island until 1800 June 4. Ice generally was observed to take six to seven hours to float down from the index site to Otter Island. Assuming that the smolt move downstream with the current or a bit faster, a six hour delay would place them at the index site around 1200, or just about the same time the net started fishing. Catch per unit of time for the 1216-1527 period started at about 180 fish per minute and climbed to a high of better than 700 fish per minute at 1400. Thereafter, it dropped rapidly and was just starting to rise again at 1527 when the ice forced removal of the net from the river.

Schools of smolt were observed migrating out under the ice during the afternoon and evening of June 4. Observations were impossible during the late evening and index hours; however, the magnitude of the afternoon's catches, combined with the fact that migration usually increases after dark, indicates that this was probably the peak of the outmigration. There is no way to estimate of what magnitude this peak might have been. An estimate was made for the 1200-2200 time period of 113,025 on the basis of directly expanding the afternoon's catch per time fished. On the basis of the following day's catches, it is felt that the peak of the run was probably not much greater than this in magnitude.

Other periods of fishing were missed due to ice when smolt were

TABLE 2. KVICHAK INDEX SITE DAILY AND ACCUMULATIVE CATCHES OF RED SALMON SMOLT, 1966

Date	1200-2200	2200-2300	2300-2400	0000-0100	Index	0100-1200	Daily Total	Accumulative Total
5/18-6/2	0	0	0	0	0	0	0	0
2-3	0	0	0	0	0	-	0	0
3-4	0	NO FISHING DUE TO ICE					0	0
4-5	113,025	" " " " "					113,025	113,025
5-6	11,136	" " " " "					11,136	124,161
6-7	3	0	28,157	7,033	35,190	19,351	54,544	178,705
7-8	1,866	15	16	23	54	3,262	5,182	183,887
8-9	1,182	15,776	10,295	4,814	30,885	4,753	36,820	220,707
9-10	0	5,032	2,378	1,247	8,657	5,250	13,907	234,614
10-11	4	8,662	15,274	8,039	31,975	1,690	33,669	268,283
11-12	2	NO FISHING DUE TO ICE					2	268,285
12-13	150	200	170	2	372	0	522	268,807
13-14		NO FISHING DUE TO ICE						
14-15		" " " " "						
15-16		" " " " "						
16-17	5,175	558	441	780	1,779	-	6,954	275,761
TOTAL	132,543	30,243	56,731	21,938	108,912	34,306	275,761	

migrating. On June 5, very small catches were made in the early afternoon. Between 1518 and 1832, after ice had forced removal of the net, large schools of smolt were observed migrating under the ice. No estimate of their numbers or of the migration later in the evening is possible. The total estimated catch of 275,761, is simply a rough approximation, but it is felt that it is at least in the general range of the numbers of fish passing the index site.

3. Age, Length and Weight of Smolt

Table 3 and Figure 3 give the length frequencies of smolt in the outmigration by age class weighted by the daily index catches. Length frequencies were determined by daily samplings and age class composition of the outmigration was determined by relating scale samples to length to arrive at the dividing point between the two age classes. Age I smolt were estimated to comprise 91.5% of the outmigration and average 94.5 mm in length. Age II smolt averaged 113.7 mm in length.

Unfortunately, sampling of individual smolt to establish a length-weight relationship was limited due to the short duration of the outmigration peak and the tremendous amount of ice interference. The 38 individual lengths and weights collected for simplicity were analyzed linearly. A predicted weight was estimated for each length represented in the outmigration and weighted by the fish frequency for that length to derive the average weights of Age I and Age II fish. Age I and Age II smolt averaged 7.4 g. and 12.6 g. respectively.

C. Analysis and Comparison with Past Data

Tables 1 through 6, Appendix A, compare the 1966 smolt outmigration index data with that of past years. As would be expected, due to the small number of fish involved, both the Age I and Age II fish were larger than the twelve-year average. Their numbers, especially of Age II fish, in the index catch were considerably lower than the twelve-year average. The Age II fish were the progeny of the small (338,760) 1963 escapement. This escapement produced only 64,377 Age I index smolt in 1965 and 24,818 Age II index smolt in 1966, for a total index smolt per spawner value of .263, well below the eleven-year average. The previous and following brood classes were quite small and therefore, there should have been very little intra-specific competition acting on the progeny of the 1963 escapement. Even so, relative production from this brood year remained well below the eleven-year average. This is further support for the thesis advanced in 1964 and 1965, that small escapements in the Kvichak do not produce very well.

Table 3. Weighted length frequencies for red salmon smolt Kvichak River index site, 1966

Length (mm)	Frequency	Length (mm)	Frequency
85	92	105	2,285
86	2,674	106	1,076
87	2,674	107	92
88	3,350	108	0
89	12,069	109	2,506
90	18,927	110	1,076
91	18,739	111	2,245
92	17,764	112	92
93	16,827	113	1,076
94	28,753	114	899
95	38,801	115	1,076
96	22,513	116	3,599
97	21,922	117	1,475
98	12,336	118	853
99	9,465	119	0
100	13,548	120	2,077
101	4,206	121	92
102	2,065	122	1,076
103	4,583	123	0
104	1,076	124	0
		125	353
		126	0
		127	0
		128	353
		129	0
		130	0
		131	1,076

Age I 252,384 Age II 23,377

Average length: 94.5 mm Average Length: 113.7 mm

Note: Age I and Age II fish overlapped in the 101-105 mm length groups.

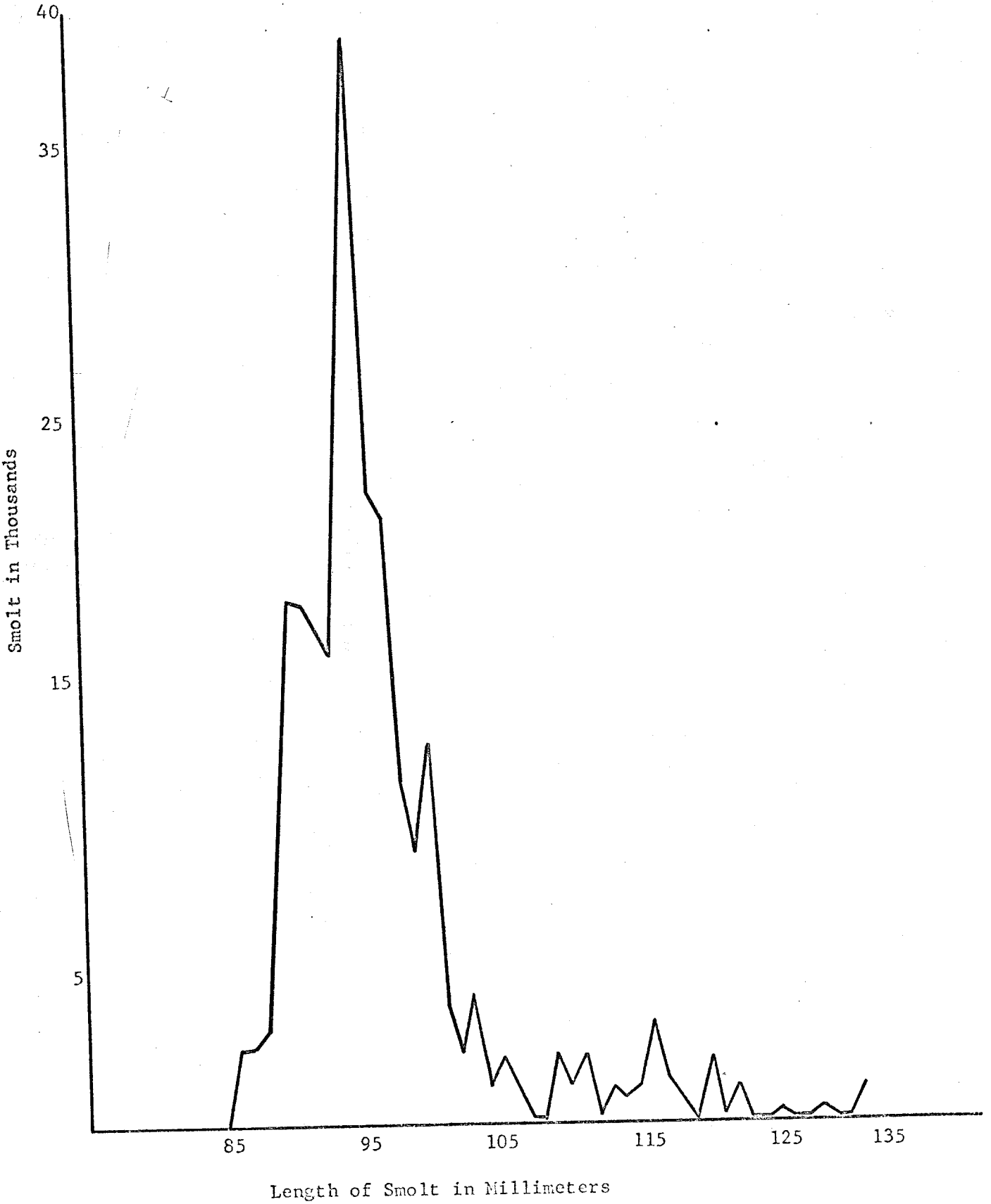

Figure 3. Weighted length frequency curve for red salmon smolt, Kvichak River, 1966

In summary, the 1966 Kvichak smolt outmigration was quite small. This was probably due to the fact that the two parent escapements contributing to it only totaled 1,295,880 spawners in a system that has been proven capable of supporting the progeny from 14,630,000 spawners in a single year. The index catch total is subject to a great deal of error due to ice interference. The total days of ice flow did not exceed that experienced in three previous years, but it came at a time when the run was thought to be peaking. Also, the main part of the migration was of such short duration (estimated 65% in three days), that ice interference at this time was especially disruptive to the accurate measurement of relative smolt abundance. In spite of this, visual observations, catches at the research site, the size of the parent escapements, and the size of the smolt themselves indicate that the estimated index catch of 275,761 is in the right range.

III. TOTAL SMOLT OUTMIGRATION ESTIMATE

A. Methods and Procedures

The search in 1966 for a suitable outmigration site relatively free from ice in the shallow, swifter current areas of the Kvichak River above Otter Island proved unsuccessful. Ice flow in this area was disruptive of fishing to a degree that would preclude any accurate estimate of total outmigration. The ice flow in 1966 was especially severe in that it filled the river for days at a time, and it came at the peak of the smolt outmigration. In most years ice flow at the lower end of Kaskanak Flats is probably minimal, but examination of Figure 1 indicates that in at least three other years, 1961, 1963, and 1964, ice flow was probably severe enough to adversely affect fishing in this area.

Discussions are underway with engineers and other scientists on possible ways to circumvent the ice flow. Ice dams, underwater photography and even submergible traps have been or are being discussed; however, at present, there does not appear to be any way to obtain an outmigration estimate unless the ice can be avoided altogether. Investigations this spring showed that the ice did not dissipate above Woody Island, some 15 miles below Otter Island.

The river at Woody Island is broad, tidal and shallow with many sand bars and a large side slough. Any form of sampling here would be extremely difficult. However, directly below this area the river constricts into a canyon approximately 3-5 miles in length. The canyon above a point known as Big Rock is fairly uniform in width and depth and the river banks are nearly parallel with only a slight curve in the channel. This area was surveyed in June and again in August to determine what measures would be necessary to obtain an outmigration estimate at this point.

In both June and August, transects of the river in the canyon were run

to obtain depth data. The river bottom was found to be fairly uniform in character with no extensive shoal areas. Table 4 presents depth and current velocity data obtained on June 7, at a point in the center of the proposed fishing area. These measurements were taken at low water. It is probable that the depth increases by as much as six feet at high tide. As can be seen, the velocity if fairly uniform across the channel. At a velocity station set up in midstream near Big Rock on June 7 and 8, a mean velocity of 2.84 feet per second and a depth of 21 feet were recorded at low water. At high water a depth of 27 feet and an upstream current of 1.80 feet per second were recorded. Neither a current reversal nor a large tidal fluctuation was observed in August, but this was probably due to the high water level of the river. Water in the canyon was fairly turbid in both June and August with visibility to only 2-3 feet. Flow measurements at Otter Island on May 31, and June 2, indicated a total flow in the Kvichak of 11,900 c.f.s. Surveys in August showed only six small streams between Otter Island and Big Rock Canyon with an accumulative flow of less than 300 c.f.s. During the smolt migration, the total river flow through the canyon probably does not exceed 15,000 c.f.s.

B. Discussion

Sampling of this canyon area to obtain an outmigration estimate presents some unique problems. Low current velocities, tidal reversal of current and depth of the river are the primary difficulties. Conventional, stationary sampling gear would be useless. A review of the problems involved, gear required, and data needed is being undertaken to determine the feasibility of obtaining an outmigration estimate under these conditions. Under Phase I of the project, a literature review is being made of gear and sampling designs used for enumerating downstream migrants in similar circumstances elsewhere. Scientists involved in this work are being personally contacted and engineers and biometricians are being consulted.

TABLE 4

RIVER MEASUREMENTS TAKEN AT A POINT
ONE MILE ABOVE BIG ROCK, KVICHAK RIVER

June 7, 1966

Distance From Left Bank (ft.)	Depth	Mean Velocity (Feet per Second)
30	10.7	1.6
80	19.0	2.0
120	20.3	2.0
140	20.5	2.2
160	20.5	2.4
220	21.0	2.3
270	21.0	2.4
340	21.0	2.2
380	12.9	2.1
440	Right Bank	
Average	18.5	2.1

ABUNDANCE, SIZE AND AGE OF RED SALMON SMOLTS FROM THE WOOD RIVER LAKES SYSTEM, 1966

By

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I. INTRODUCTION

The Wood River red salmon smolt program was conducted during the summer of 1966, for the sixteenth consecutive year at Mosquito Point, Lake Aleknagik. Catches from a standard fyke net were used to determine abundance, age and size composition of red salmon smolt.

The primary objective was to measure relative abundance of smolts migrating seaward from the Wood River Lakes by establishing a numerical index which is comparable from year to year. Other objectives were to study diurnal fluctuations and seasonal timing of migrations, to obtain age and size composition of the run and to evaluate the relationship of smolt production and adult escapement levels.

Fyke net operations were begun on June 6, the day after lake ice breakup and were terminated on July 14. Fishing was conducted every evening from 9 to 11 p.m., during the season except on July 11, when operations were suspended due to high winds. Five-hour fishing periods from 9 p.m. to 2 a.m. were conducted frequently throughout the season to obtain information regarding efficiency of the 2-hour index and diurnal fluctuations of the migration pattern.

Condition index and 24-hour sampling were discontinued during the 1966 season. Collection and computations of field data otherwise remained similar to methods employed during previous years (Nelson, 1966).

The United States Geological Survey, (Water Resources Division) established an automatic flow recorder during the fall of 1965, on Wood River at the outlet of Lake Aleknagik. Daily water discharge, in c.f.s. were recorded at this site throughout the season. Maximum flow recorded on June 15 was approximately 11,380 c.f.s. and a minimum flow of 6,900 c.f.s. was recorded on August 6, 1966. River flow readings during 1966 correspond closely to data gathered in previous years by Alaska Department of Fish and Game field crews (Nelson, 1966). The water level for Lake Aleknagik peaked on June 18, 1966, at 18.0 inches, which was less than the

1964 and 1965 readings (Figure 1).

Field work in 1966 was under the supervision of the writer. Mr. Michael L. Nelson, Assistant Area Biologist, assisted the writer with the report as well as aging smolt scales. Participants in the program were Mr. Robert Lackey, who served as crew leader and messrs: Russell Archer, Harry Rodoni, Jerome Sexton, and Albert Byrne.

A. Results

1. Index of Abundance

Total catch of red salmon smolt during the index hours for the entire season was 250,049 (Table 1). Using 1952 as the base year with the assigned value of 100.00 index points, the 1966 season's catch was equivalent to 147.1 index points (Table 1). Relative magnitude of the smolt runs in the Wood River system from 1951 through 1966 is shown in Figure 2.

Catches during the index hours followed the usual pattern, with the lowest total catch being realized during the first hour (28.19%) and increasing during the second hour (71.81%). The adjusted index which eliminates yearly fluctuations was 133.4 as shown in Table 1, Appendix B. Peak period of smolt outmigration was June 24-27, when 54.7 percent of the season's total catch was caught. The peak day of outmigration was on June 27 when 72,369 smolt were taken or 28.9 percent of the season's total catch (Figure 3).

Five-hour fishing periods were conducted for 27 days during the 39-day smolting season. Total catch for the 5-hour fishing period was 480,520 (Table 2). Percent of smolt caught during the 5-hour fishing period was comparable to previous years, especially 1958 (Table 1, Appendix B). The adjusted season's total 5-hour smolt catch was 527,908 (Table 1, Appendix B). The equation for expressing adjusted 5-hour data is discussed in Nelson, 1965.

Percentage of the catch taken during the index period compared to the 5-hour sampling period is shown below for years in which data is available:

1955..... 43.0	1959..... 42.0
1956..... 43.3	1964..... 73.6
1957..... 37.4	1965..... 31.6
1958..... 46.4	1966..... 47.4

Hourly percentages of red salmon smolt catches for the above years are given in Table 2, Appendix B (Koo, 1959-60).

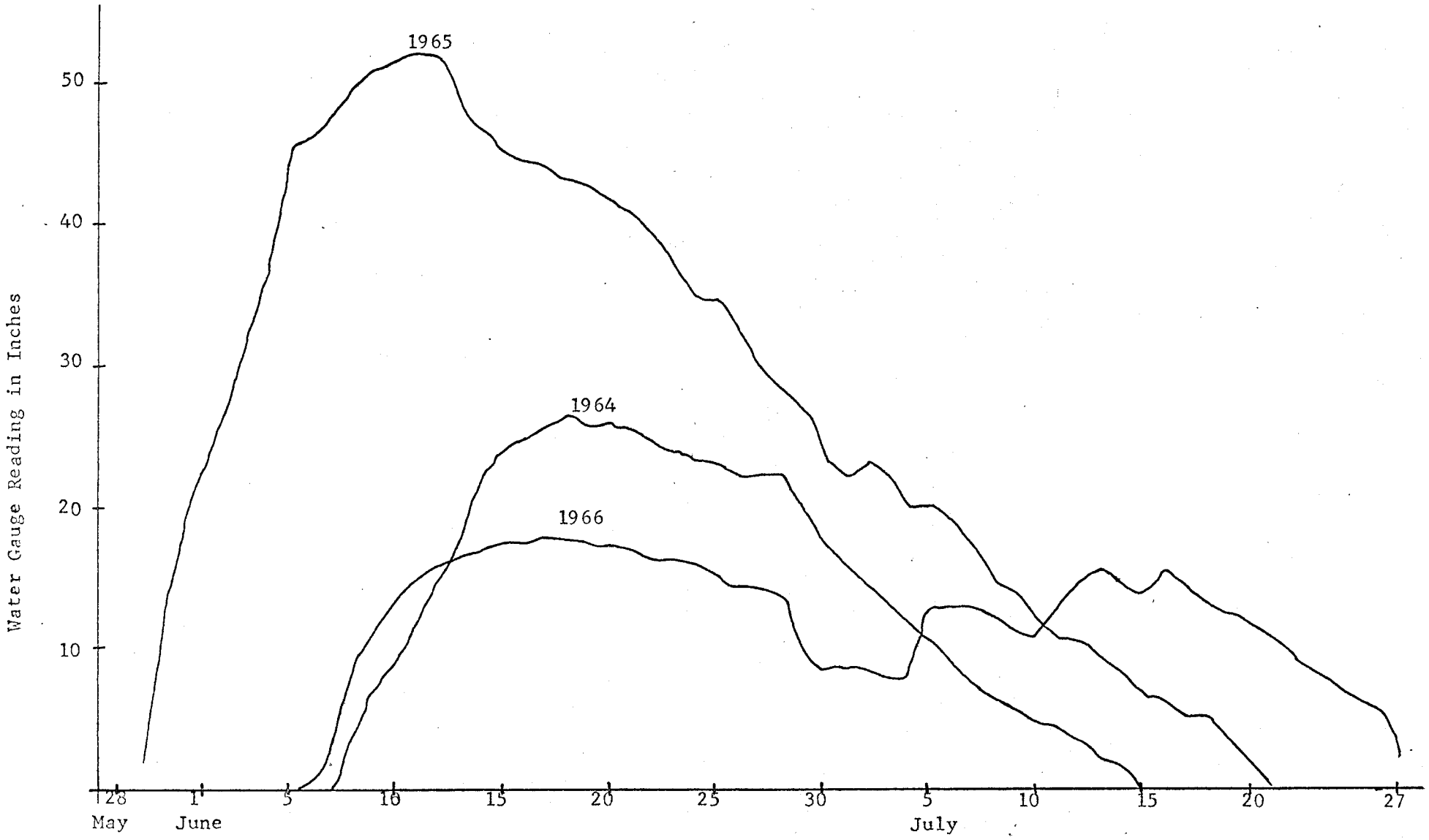

Figure 1. Wood River water gauge readings, 1964-66. (Water level measured in inches and tenths of inches from a fixed bench mark on the bank).

Table 1. Wood River Red Salmon Smolt Catch by Hour and Day, 1966

Date		Index Hour Catch 2100-2200	Index Hour Catch 2200-2300	Total Index Catch Daily	Total Index Catch Cumulative	Index Points 1/ Daily	Index Points 1/ Cumulative
June	6	1	33	34	34	0.02	0.02
	7	124	25	149	183	0.09	0.11
	8	8	363	371	554	0.22	0.33
	9	49	140	189	743	0.11	0.44
	10	14	964	978	1,721	0.58	1.02
	11	0	864	864	2,585	0.51	1.53
	12	640	1,294	1,934	4,519	1.14	2.67
	13	1,075	1,447	2,522	7,041	1.48	4.15
	14	4	332	336	7,377	0.20	4.35
	15	7	96	103	7,480	0.06	4.41
	16	7,397	7,366	14,763	22,243	8.68	13.09
	17	4,479	13,146	17,625	39,868	10.37	23.46
	18	158	173	331	40,199	0.19	23.65
	19	384	4,053	4,437	44,636	2.61	26.26
	20	667	14,295	14,962	59,598	8.80	35.06
	21	291	34	325	59,923	0.19	35.25
	22	1,386	936	2,322	62,245	1.37	36.62
	23	6,981	1,310	8,291	70,536	4.88	41.50
	24	3,787	9,048	12,835	83,371	7.55	49.05
	25	8,495	23,731	32,226	115,597	18.95	68.00
	26	13,247	6,003	19,250	134,847	11.32	79.32
	27	15,781	56,588	72,369	207,216	42.56	121.88
	28	208	796	1,004	208,220	0.59	122.47
	29	1,123	1,137	2,260	210,480	1.33	123.80
	30	6	116	122	210,602	0.07	123.87
July	1	3	10	13	210,615	0.01	123.88
	2	0	81	81	210,696	0.05	123.93
	3	313	1,090	1,403	212,099	0.83	124.76
	4	9	2,719	2,728	214,827	1.60	126.36
	5	0	7,875	7,875	222,702	4.63	130.99
	6	108	3,439	3,547	226,249	2.09	133.08
	7	0	1,598	1,598	227,847	0.94	134.02
	8	587	2,420	3,007	230,854	1.77	135.79
	9	1,637	4,079	5,716	236,570	3.36	139.15
	10	1,162	9,921	11,083	247,653	6.51	145.66

Table 1. Wood River Red Salmon Smolt Catch by Hour and Day, 1966

(Continued)

Date	Index Hour Catch 2100-2200	Index Hour Catch 2200-2300	Total Index Catch Daily	Total Index Catch Cumulative	Index Points 1/ Daily	Index Points 1/ Cumulative
July 11	--	--	--	247,653	--	145.66
12	12	74	86	247,739	0.05	145.71
13	340	1,025	1,365	249,104	0.80	146.51
14	0	945	945	250,049	0.56	147.07
TOTALS	70,483	179,566	250,049	250,049	147.07 2/	147.07 2/
PERCENT	28.19	71.81	100.00			

1/ One index point = 1,700.34 smolt

2/ Unadjusted index

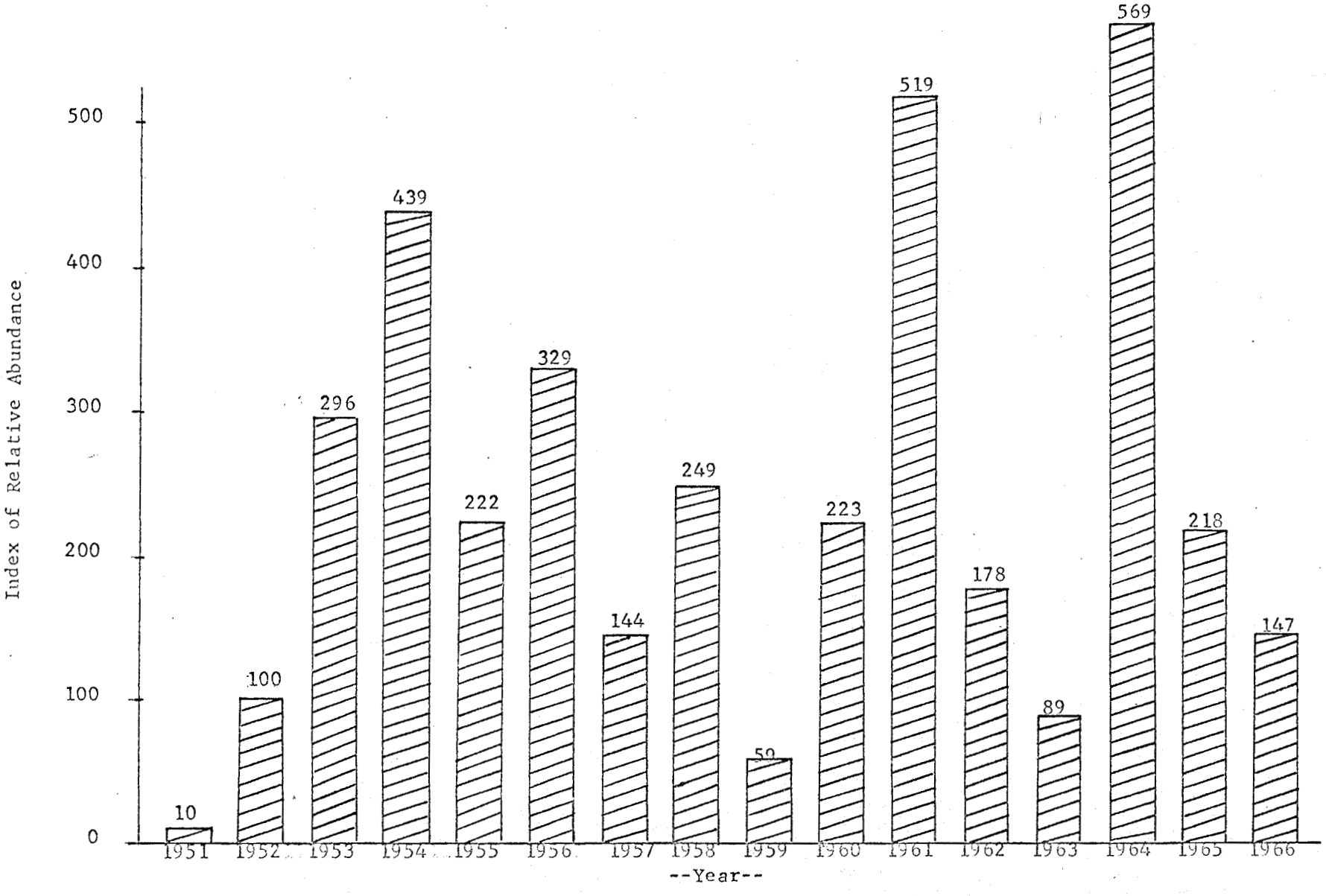

Figure 2. Relative magnitude of red salmon smolt outmigrations from the Wood River system, 1951-66.

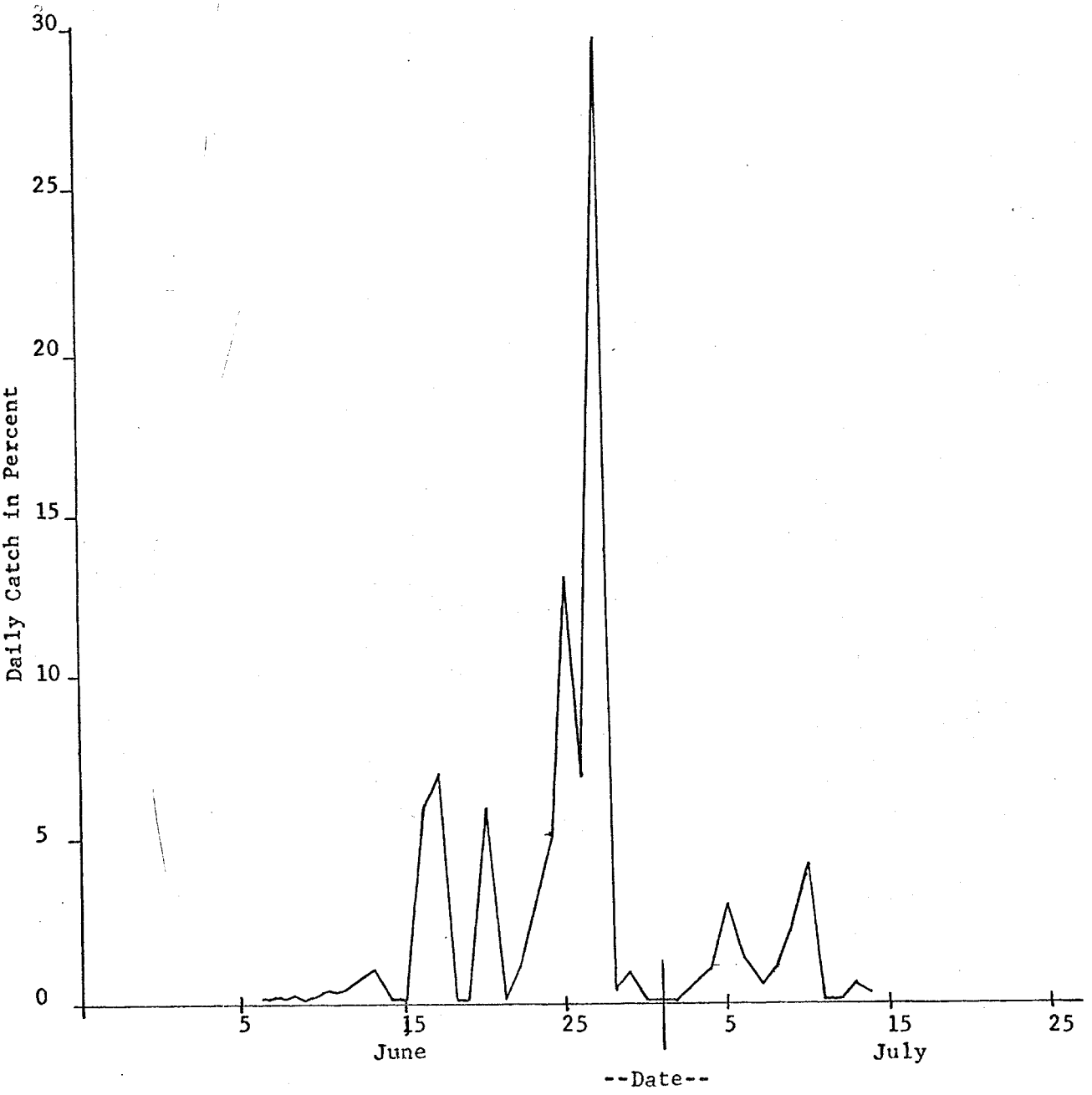

Figure 3.. Daily catches of red salmon smolt in percent of total catch from the Wood River system, 1966.

Table 2. Wood River Red Salmon Smolt Catch
In Index Net for 5-hour Period, 1966

Date	Time Period 2100-2200	2200-2300	2300-0000	0000-0100	0100-0200	Total Catch
June 9-10	49	140	305	391	118	1,003
12-13	640	1,294	877	581	246	3,638
15-16	7	96	1,219	1,354	678	3,354
17-18	4,479	13,146	8,705	12,457	11,671	50,458
18-19	158	173	2,850	6,248	4,384	13,813
19-20	384	4,053	9,370	8,553	7,379	29,739
20-21	667	14,295	3,324	452	299	19,037
21-22	291	34	1,998	2,520	3,634	8,477
22-23	1,386	936	9,586	6,983	1,223	20,114
23-24	6,981	1,310	455	112	71	8,929
24-25	3,787	9,048	5,860	2,202	223	21,120
25-26	8,495	23,731	12,336	9,173	15,630	69,365
26-27	13,247	6,003	2,439	459	1,035	23,183
27-28	15,781	56,588	19,902	763	2,772	95,806
28-29	208	796	682	91	2	1,779
29-30	1,123	1,137	7,013	4,212	563	14,048
July 30-1	6	116	58	42	41	263
1-2	3	10	5	42	20	80
4-5	9	2,719	11,126	2,014	800	16,668
5-6	0	7,875	14,832	463	90	23,260
6-7	108	3,439	5,567	452	222	9,788
7-8	0	1,598	1,548	933	427	4,506
8-9	587	2,420	2,551	1,126	125	6,809
9-10	1,637	4,079	3,162	1,987	505	11,370
10-11	1,162	9,921	7,240	257	575	19,155
12-13	12	74	263	103	22	474
13-14	340	1,025	2,119	552	248	4,284
TOTALS	61,547	166,056	135,392	64,522	53,003	480,520
PERCENT	12.81	34.55	28.18	13.43	11.03	100.00

2. Age, Length and Weight of Smolt

Size composition was determined from length measurements of 5,516 smolts contained in 53 one-pound samples. Age determination was based on readings of 730 scales contained in 37 daily scale samples (Table 3). Combined weighted length frequencies for each period are shown in Figure 4, with the dividing line between Age I and Age II smolts, as determined from scale readings indicated by vertical dashes. These frequencies were calculated in percentages. The seasons weighted length frequency distribution is shown in Figure 5.

The percentage, length, and weight of each age group were calculated for each period and for the entire season (Table 4). Age I smolts comprised 94.3. Age II smolts comprised 5.7 percent of the run and averaged 101.2 mm in length and 7.5 grams in weight (Table 4).

Table 1, Appendix B, summarizes comparative age, length and index catches for the years 1951 through 1966. Age I smolt were the smallest since 1957 (Table 1, Appendix B). Average length and weight of both smolt age groups compared to the previous 5 years, is shown in Table 3, Appendix B.

The annual incidence of smolts parasitized by the cestode, Triaenophorous crassus, was determined by external observations. In 1966, 22.5 percent of the 5,516 smolt examined were infested with the parasite (Table 4, Appendix B).

The 1966 smolt run originated from the adult spawning escapements of 721,000 in 1963 and 1,076,000 in 1964 with the major portion of the outmigration (94.3%) being derived from the 1964 escapement. Table 5, Appendix B, gives the relationship between parent escapement of red salmon to the spawning grounds of the Wood River Lakes and relative numbers of smolts produced.

B. Discussion

Using the 2-hour smolt index to predict adult red salmon return the following is presented:

Year	Predicted Return	Actual Return 1/	(Return/Pred.) x 100
1961	1,000,000	703,000 1/	70.3%
1962	1,200,000	2,182,000 1/	181.8%
1963	2,100,000	1,255,000 1/	59.8%
1964	1,400,000	2,151,000 1/	153.6%
1965	970,000	1,144,000 2/	117.9%

1/ Burgner, R. L., 1965

2/ Pennoyer, S. and Mel Seibel, 1966

Table 3. Wood River Red Salmon Smolt Sampling Data, 1966

Period No.	Date	Smolt Catch	Percent of Season's Total	No. of 1 lb. Samples Measured	No. of Fish Measured	No. of Scales Read
1	June 6-10	1,721	0.69	4	381	80
2	June 11-15	5,759	2.30	7	844	100
3	June 16-20	52,118	20.84	10	1,089	100
4	June 21-25	55,999	22.40	9	912	100
5	June 26-30	95,005	37.99	7	803	100
6	July 1-5	12,100	4.84	4	310	90
7	July 6-14	27,347	10.94	12	1,177	160
	TOTAL	250,049	100.00	53	5,516	730

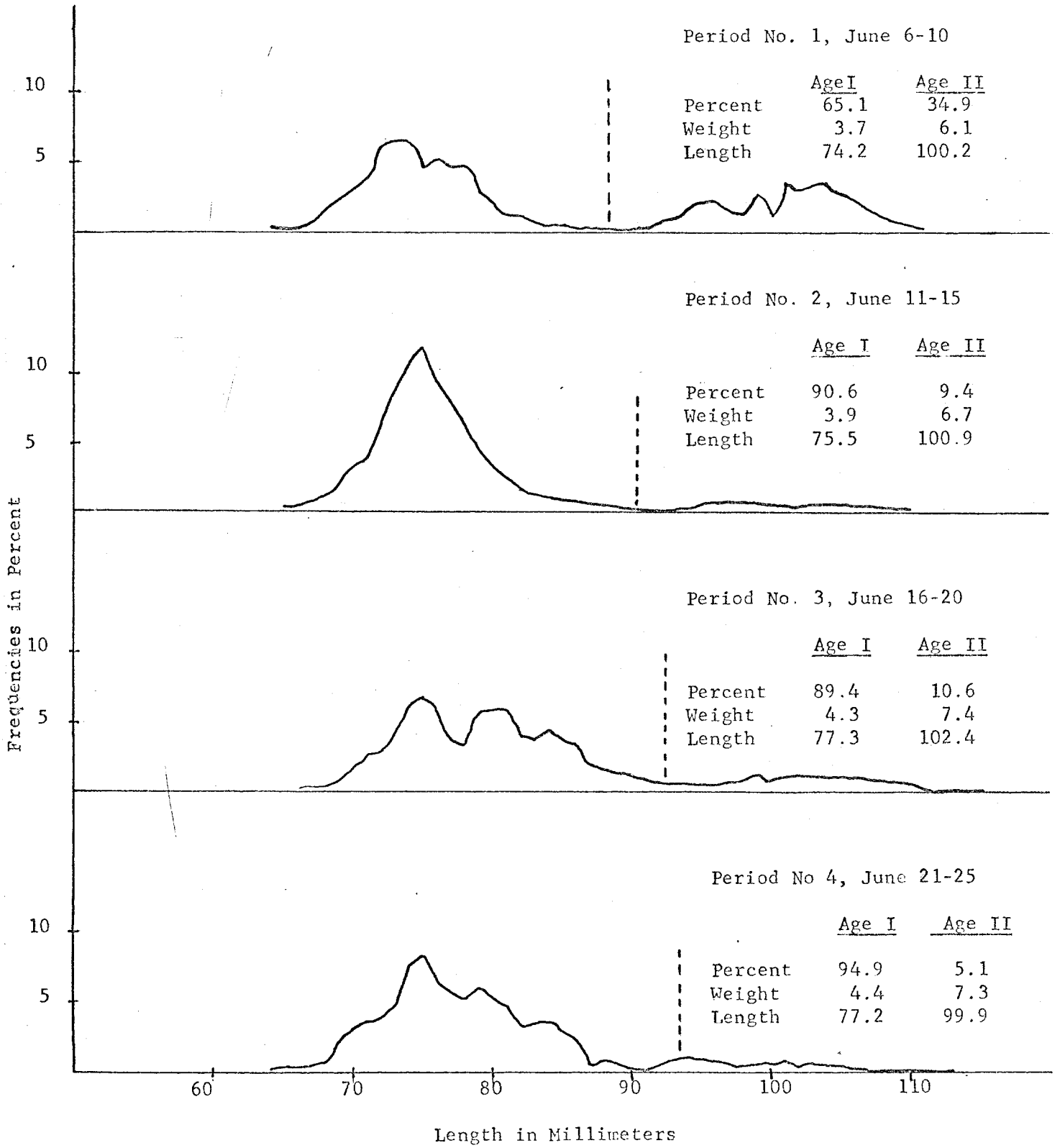

Figure 4. Weighted length frequencies by period of red salmon smolt from the Wood River system, 1966. (Vertical dash lines divide Age I and Age II). (Frequencies smoothed by moving averages of threes).

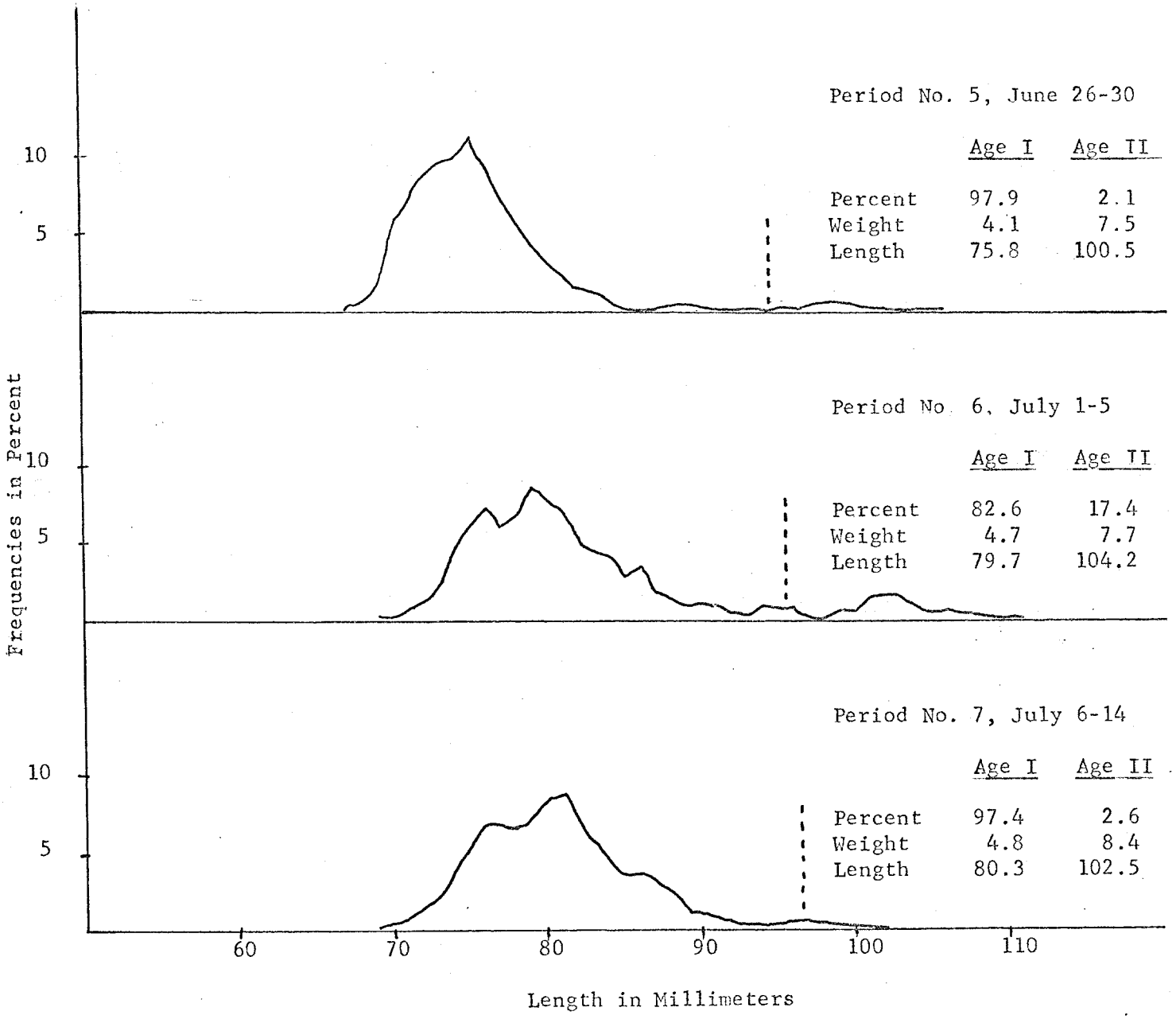

Figure 4. (cont.) --Weighted length frequencies by period of red salmon smolt from the Wood River system, 1966.

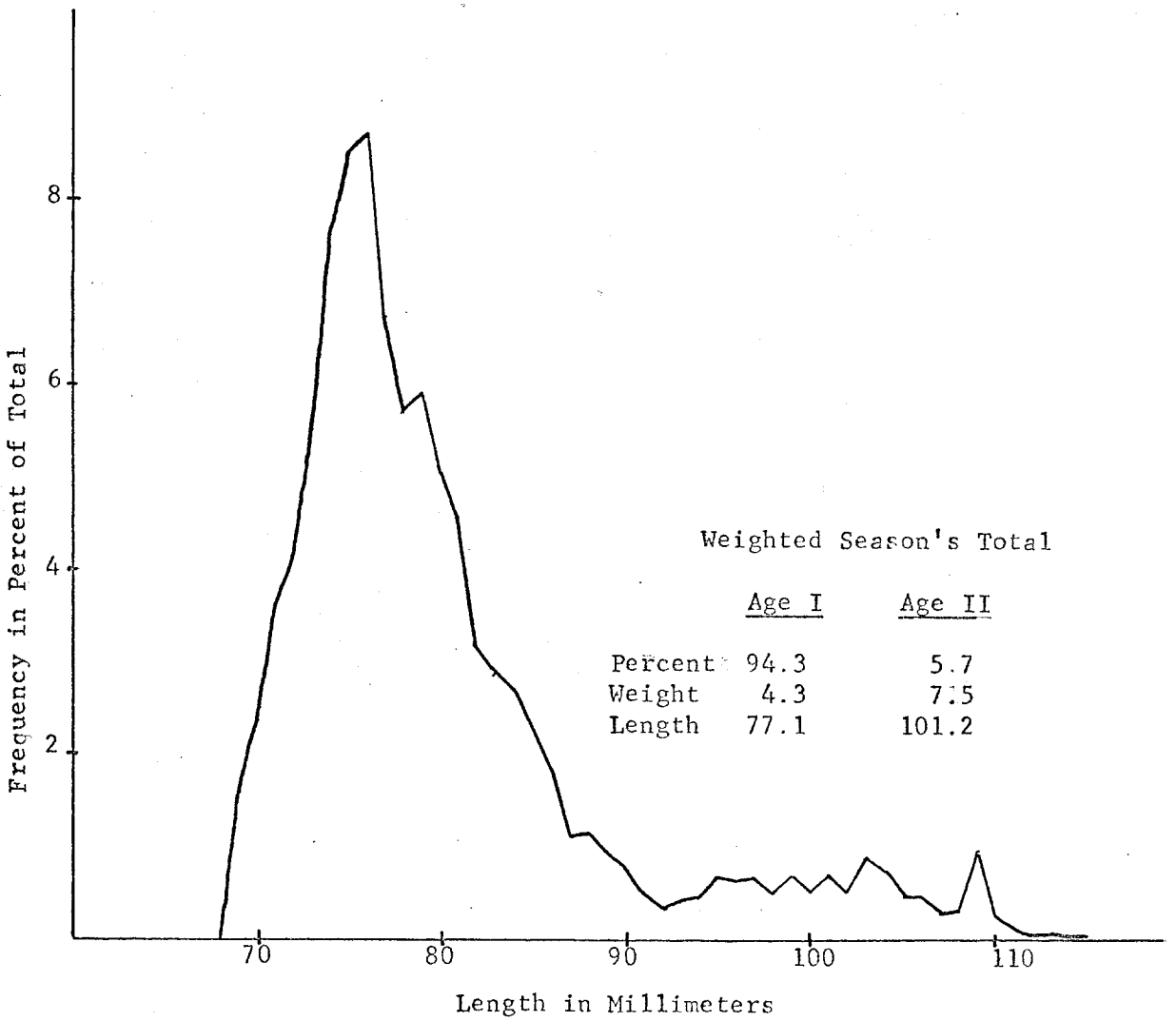

Figure 5. Season's weighted length frequency of red salmon smolt from the Wood River system, 1966. (Frequencies smoothed by moving average of threes)

Table 4. Age 1/, Length 2/, and Weight 3/ of Red Salmon Smolts by Period from the Wood River System, 1966

Period No.	Date	Line Dividing Age I & Age II	Mean Length of Age Group I	Mean Length of Age Group II	Mean Weight of Age Group I	Mean Weight of Age Group II	Percentage of Age Group I	Percentage of Age Group II
1	June 6-10	88.5	74.2	100.2	3.7	6.1	65.1	34.9
2	June 11-15	90.5	75.5	100.9	3.9	6.7	90.6	9.4
3	June 16-20	92.5	77.3	102.4	4.3	7.4	89.4	10.6
4	June 21-25	93.5	77.2	99.9	4.4	7.3	94.9	5.1
5	June 26-30	94.5	75.8	100.5	4.1	7.5	97.9	2.1
6	July 1- 5	95.5	79.7	104.2	4.7	7.7	82.6	17.4
7	July 6-14	96.5	80.3	102.5	4.8	8.4	97.4	2.6
Season's Weighted Total		4/	77.1	101.2	4.3	7.5	94.3	5.7

1/ Number winters in fresh water.

2/ Length in mm.

3/ Weight in grams

4/ Weighted by index catch

The index of accuracy (calculated by dividing the actual return by the predicted return x 100) helps demonstrate fluctuating tendencies of the 2-hour smolt index data for predicting adult return. Index of accuracy during the past 5 years has ranged between 59.8 percent to 181.8 percent.

Due to many variables affecting the smolt outmigration--climatic conditions, changes in relative numbers in the sub-population of smolts from the lake, differences between size and age of smolt and differences in rate of growth in early summer--the Department is seeking to find a method of smolt analysis that will effectively represent the actual outmigration.

It was determined from earlier studies (Burgner, 1962; Nelson, 1966) that 86 to 99 percent of the 24-hour smolt catch was made during the 5-hour period from 9 p.m. to 2 a.m. (Nelson, 1966). Changing from the 2-hour index sampling period to the 5-hour period may bring the predicted return closer to the actual return and the 5-hour index may reduce the effects that climatic factors tend to induce during the 2-hour index.

C. Summary

1. The Alaska Department of Fish and Game conducted the smolt enumeration and sampling program for the sixth consecutive year in 1966.

2. Breakup occurred on June 5 at Lake Aleknagik, which was 5 days later than the mean date for breakup of lake ice.

3. Flow measurements for Wood River were taken daily from a permanent site established by the United States Geological Survey, (Water Resources Division). Comparable water level recordings were taken for the third consecutive year.

4. The fyke net was fished during the previously established index hours of 9 to 11 p.m. each night from June 6 through July 14. In addition, frequent 5-hour counts were made to establish a basis for comparing the seasonal variations outside the index hours.

5. Five-hour fishing periods in 1966 showed that 47.4 percent of the smolt passed the fyke net site during the 2-hour index period. The peak of smolt outmigration was on June 27 when 28.9 percent of the season's total smolt were caught. The total catch of 250,049 smolt was equal to 147.0 index points.

6. Adjustments of the index, to compensate for some of the fluctuations in migration outside of index hour sampling that occur from year to year, resulted in an adjusted index value of 133.4 for 1966.

7. Size composition was determined from length measurements of 5,516 smolts contained in 53 one-pound samples. Age determination was based on readings of 730 scales contained in 35 daily scale samples.

8. Age I smolts comprised 94.3 percent of the total run and averaged 77.1 mm in length and 413 grams in weight. Age II smolts comprised 5.7 percent of the run and averaged 101.2 mm in length and 7.5 grams in weight.

9. The parasitic cestode Triaenophorous crassus, was found in 22.5 percent of the 5,516 smolts examined.

10. The 1966 smolt run originated from adult spawning escapements of 721,000 in 1963 and 1,076,000 in 1964.

NAKNEK RIVER RED SALMON SMOLT STUDY, 1966

By

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A sampling program for the enumeration of Naknek River red salmon (Onchorhynchus nerka) smolt outmigration was developed and operated by the U. S. Fish and Wildlife Service during the years 1956 through 1965. In 1966 this project was transferred to the Alaska Department of Fish and Game and was operated by the Division of Commercial Fisheries under the direct and participating supervision of Herbert W. Jaenicke, Fishery Research Biologist, U.S. Fish and Wildlife Service. Supervision for the State was conducted by Angus D. Robertson, Fishery Biologist, Alaska Department of Fish and Game.

The Naknek smolt study program design and methods [1] followed in 1966 were the same as those developed by the Fish and Wildlife Service and consisted of (1) a randomized sampling latin square scheme employing 6 fyke net fishing sites for the derivation of a total outmigration estimate and; (2) employing a single fyke net index scheme located on the most productive fishing site at the randomized sampling location. The index of abundance obtained is the basis for expanding the random sampling estimate of total numbers of smolts for the daylight hours when the random sampling is not conducted.

In 1966 randomized sampling was conducted during the most productive hours, 2100-0600, successively two days out of every three day period from June 2 through July 13. The index sampling was fished continuously for 24 hours, 2100-2100, on the second day of each two-day random sampling period.

Physical data was collected for air and water temperatures, wind direction and velocity, river discharge and velocities at varying water levels.

All 1966 Naknek smolt study data was compiled and the total outmigration estimate derived by Herbert Jaenicke. The following data tables have been extracted and compiled from Mr. Jaenicke's work.

[1] Jaenicke, Herbert W., Naknek Smolt Study Report, 1956-1965, U.S. Fish and Wildlife Service, unpublished.

TABLE 1. NAKNEK RIVER RANDOM SAMPLING CATCHES[1/] OF RED SALMON SMOLT BY FISHING SITE, 1966

Date	Sampling Site 1	2	3	4	5	6	Daily Total Percent	No. Smolts
June 2	1	0	20	0	30	11	.06	62
3	72	114	62	1,484	4	96	1.85	1,832
5	4	0	0	2,553	1,204	3,660	7.47	7,421
6	0	0	487	5,684	1,593	164	7.99	7,928
8	216	3,756	2,579	2,148	323	220	9.31	9,242
9	5	411	458	1,122	85	25	2.12	2,106
11	101	1,816	1,852	4,715	1,575	609	10.74	10,668
12	623	1,598	730	2,879	951	658	7.49	7,439
14	78	54	957	7,154	914	81	9.31	9,238
15	256	315	1,115	7,085	117	3,157	12.13	12,045
17	558	130	979	85	1,488	5	3.27	3,245
18	302	0	1,590	3,465	4,624	167	10.22	10,148
20	197	1,292	2,139	1,572	356	112	5.71	5,668
21	14	891	1,591	1,015	925	358	4.83	4,794
23	0	55	0	523	773	0	1.36	1,351
24	11	151	169	0	672	21	1.03	1,024
26	111	148	0	0	45	173	.48	477
27	0	0	100	346	26	34	.51	506
29	95	32	861	0	43	28	1.07	1,059
July 2	44	32	136	59	52	23	.35	346
4	12	5	15	57	12	4	.11	105
5	13	53	42	19	26	29	.18	182
7	0	25	28	29	7	5	.09	94
8	4	18	1,267	471	15	1	1.79	1,776
10	-	7	53	34	14	-	.11	108
11	19	4	0	19	64	2	.11	108
13	15	20	64	141	59	7	.31	306
Totals	2,751	10,927	17,294	42,659	15,997	9,650		99,278
%	2.77	11.01	17.42	42.97	16.11	9.72		100.00

[1] All catches standardized to 90-minute fishing periods.

TABLE 2. NAKNEK RIVER INDEX NET[1] CATCHES OF RED SALMON SMOLT BY ~~90~~-MINUTE PERIODS, JUNE 3 - JULY 6, 1966

Fishing Period	Date											Total	%
	June 3-4	June 6-7	June 9-10	June 12-13	June 15-16	June 18-19	June 21-22	June 24-25	June 27-28	July 2-3	July 5-6		
2100-2230	27	0	1,695	0	820	5	106	0	0	158	98	2,909	2.11
2230-2400	486	1,100	317	2,007	1,406	473	1,032	43	161	92	142	7,259	5.26
0000-0130	931	2,469	1,326	4,310	4,466	3,017	2,257	1,452	350	125	156	20,859	15.10
0130-0300	682	4,579	4,641	5,914	1,773	4,866	4,720	558	583	114	19	28,449	20.60
0300-0430	182	1,855	1,110	5,215	5,627	3,576	586	408	227	61	70	18,917	13.70
0430-0600	541	513	501	2,763	9,663	2,317	364	56	108	116	93	17,035	12.34
0600-0730	319	1,011	430	5,291	9,310	1,008	347	128	17	102	22	17,985	13.02
0730-0900	67	12	233	1,367	102	1,144	53	832	54	153	17	4,034	2.92
0900-1030	19	462	210	671	676	1,750	8	767	53	51	0	4,667	3.38
1030-1200	11	6	0	490	270	22	104	0	57	102	0	1,062	.77
1200-1330	0	0	5	2,389	8	3	0	23	3	23	0	2,454	1.78
1330-1500	7	1	1	2,930	0	49	1	5	0	6	0	3,000	2.17
1500-1630	4	1	0	328	2,089	1	0	63	0	227	0	2,713	1.96
1630-1800	0	0	15	651	567	0	0	12	0	175	1	1,421	1.03
1800-1930	8	3	1	456	1,901	1	0	1	0	64	206	2,641	1.91
1930-2100	5	2	999	200	1,283	2	1	0	0	151	49	2,692	1.95
Total	3,289	12,014	11,484	34,982	39,961	18,234	9,579	4,348	1,613	1,720	873	138,097	100.00

[1] Site 4

TABLE 3. LENGTH-WEIGHT BY AGE CLASS OF NAKNEK RIVER RED SALMON SMOLT SAMPLED, 1966

Date	Age I No. Smolts	Age I Length mm	Age I Weight grams	Age I Percent	Age II No. Smolts	Age II Length mm	Age II Weight grams	Age II Percent
May 31	2	108	11.4	22.2	7	126	17.0	77.8
June 2	7	111	11.4	21.9	25	121	15.4	78.1
3	2	111	12.3	5.0	38	122	15.3	95.0
5	-	-	-	-	20	127	17.2	100.0
6	3	113	13.0	7.5	37	125	16.5	92.5
8	2	112	11.1	5.0	38	121	14.9	95.0
9	3	114	12.5	7.5	37	119	14.2	92.5
11	-	-	-	-	39	121	14.8	100.0
12	12	113	12.6	31.6	26	117	13.6	68.4
14	11	112	12.2	28.2	28	114	13.1	71.8
15	17	109	11.9	42.5	23	112	12.4	57.5
17	19	106	10.5	48.7	20	110	11.5	51.3
18	25	106	10.7	62.5	15	108	11.6	37.5
20	15	103	9.1	78.9	4	104	9.5	21.1
21	25	103	9.8	62.5	15	107	11.1	37.5
23	16	98	8.4	80.0	4	102	9.2	20.0
24	18	100	8.6	90.0	2	104	10.1	10.0
26	32	100	8.7	94.1	2	99	7.9	5.9
27	38	101	8.8	95.0	2	103	9.3	5.0
29	39	100	9.3	97.5	1	113	12.9	2.5
30	14	105	10.5	70.0	6	108	11.5	30.0
July 2	35	101	10.1	87.5	5	101	9.7	12.5
4	27	104	10.0	90.0	3	103	10.2	10.0
5	39	105	9.8	97.5	1	107	10.0	2.5
7	10	102	8.9	90.9	1	103	9.4	9.1
8	38	106	10.5	95.0	2	111	12.0	5.0
10	33	107	10.6	91.7	3	111	11.8	8.3
11	20	108	10.7	90.9	2	107	10.5	9.1
13	22	108	11.1	88.0	3	112	12.7	12.0
Total	524				409			
*		106	10.6	33.8*		118	14.2	66.2*

* Weighted by randomized catches with May 31 and June 30 samples not included as weighting factor not comparable.

TABLE 4. AVERAGE FORK LENGTHS AND WEIGHTS, NAKNEK RIVER RED SALMON SMOLTS, 1957-1966

Year of Seaward Migration	Age I		Age II	
	Length in mm.	Weight in grams	Length in mm.	Weight in grams
1957	111	13.1	112	13.1
1958	91	6.9	114	11.3
1959	97	8.2	106	10.1
1960	99	8.8	109	11.9
1961	103	10.8	113	13.8
1962	105	10.4	112	12.5
1963	98	8.1	114	12.8
1964	97	7.7	110	11.0
1965	99	8.4	114	13.0
1966	106	10.6	118	14.2
Mean Average	101	9.3	112	12.4

TABLE 5. PRODUCTION OF RED SALMON SMOLTS BY BROOD YEAR, NAKNEK RIVER, 1956 - 1964 [1]

Brood Year	Escapement	Smolts Produced at Age I	II	III	Total
1956	1,772,593	9,698,033	2,430,770	20,074	12,148,877
1957	634,655	10,034,717	3,118,182	-	13,152,899
1958	278,118	3,553,121	1,246,008	-	4,799,129
1959	2,231,807	4,366,639	8,461,579	134,108	12,962,326
1960	828,381	8,000,637	8,717,000	7,228	16,724,865
1961	351,078	6,049,747	4,973,098	88,951	11,111,796
1962	723,066	2,248,013	9,878,527	-	12,126,540
1963	905,358	14,741,194	6,098,025	-	20,839,219
1964	1,349,604	3,114,885	[2]		
1965	717,798				
1966	1,016,445				

[1] Production from 1954 and 1955 brood years were only partially sampled in 1956 and 1957.

[2] Age II smolt to migrate in 1967.

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APPENDIX A

TABLE 1

DATES OF SAMPLING AND PEAK PERIODS OF RED SALMON SMOLT OUTMIGRATION KVICHAK RIVER, 1955-1966

Year	Date	Number of Days	Date	Number of Days	Percent of Total Catch
1955	5/28-6/27	31	6/4-9	6	94%
1956	5/24-7/4	42	6/1-9, 14-16	12	88
1957	5/28-7/24	58	5/28-6/6	10	84
1958	5/10-7/5	56	5/22-6/3	13	80
1959	5/23-6/28	36	5/26-6/2	8	98
1960	5/18-6/19	33	5/28-6/4	8	80
1961	5/23-6/20	29	5/23-6/2	11	81
1962	5/27-7/4	39	6/2-15	14	88
1963	5/16-6/16	32	5/24-29 6/7-9	9	86
1964	5/19-6/22	35	6/4-12	9	84
1965	5/17-6/14	28	5/24-30	6	91
1966	5/18-6/17	31	6/4-11	8	97
Averages		38		10	88

TABLE 2

PERCENT OF RED SALMON SMOLT OUTMIGRATION OCCURRING DURING INDEX HOURS (2200-0100)
KVICHAK RIVER, 1955-1966

Year	Total 24-Hour Outmigration 1/	Percent Outmigration During Index Hours (2200-0100)
1955	259,978	82.3%
1956	77,660	82.3
1957	30,907	82.3
1958	3,333,953	57.4
1959	2,863,876	57.4
1960	614,003	74.1
1961	36,164	82.3
1962	1,203,000	25.1
1963	4,229,431	32.6
1964	2,061,586	38.3
1965	1,812,555	46.9
1966	275,761	39.5 2/
Averages	1,399,906	58.4 3/

1/ The methods used to expand the 3-hour index catches to 24-hour catches for the years 1955,1956,1959, 1960 and 1961 are explained in the 1964 smolt report.

2/ This figure is nearly meaningless since ice flow precluded any estimate of comparative migration by period.

3/ Note that the average 58.4% migration during the index hours is probably high as the percent for three of the four years showing 82.3% was assumed on the basis that 82.3% of the smolt in 1957 migrated during the index hours. Sampling was not on a 24-hour basis for the years 1955, 1956, 1959, 1960 and 1961.

TABLE 3

KVICHAK RIVER 3-HOUR RED SALMON SMOLT CATCHES; 1955-1966

3-Hour Index Catches

Year of Outmigration	Age I Number	Age I Percent	Age II Number	Age II Percent	Total Number	Total 3-Hour Index[1/]
1955	14,971	7	198,897	93	213,868	6.4
1956	24,916	39	38,970	61	63,886	1.9
1957	18,306	72	7,119	28	25,425	0.8
1958	1,874,512	98	38,255	2	1,912,767	57.4
1959	49,292	3	1,593,781	97	1,643,073	49.3
1960	45,478	10	409,305	90	454,783	13.6
1961	21,420	72	8,330	28	29,750	0.9
1962	283,328	94	18,085	6	301,413	9.0
1963	41,424	3	1,339,379	97	1,380,803	41.4
1964	173,919	22	616,623	78	790,542	23.7
1965	34,009	4	816,212	96	850,221	25.5
1966	100,199	92	8,713	8	108,912	3.3
Twelve-Year Averages	223,481	43	424,472	57	647,954	19.4

1/ One Index Point = 33,340 Smolt

TABLE 4

KVICHAK RIVER 24-HOUR RED SALMON SMOLT CATCHES
AVERAGE LENGTHS AND WEIGHTS, 1955-1966

Outmigration	Age I Number	Age I 2/ Percent	Age I Average Length	Age I Weight	Age II Number	Age II Percent	Age II Average Length	Age II Weight	Total Number	1/ Total 24-Hour Index
1955	18,198	7	89 mm	-	241,780	93	109 mm	-	(259,978) 3/	7.8
1956	30,287	39	92 mm	-	47,373	61	116 mm	-	(77,660) 3/	2.3
1957	22,253	72	96 mm	7.3 g	8,654	28	120 mm	14.4 g	30,907	0.9
1958	3,267,274	98	84 mm	4.6 g	66,679	2	114 mm	-	3,333,953	100.0
1959	85,916	3	80 mm	-	2,777,960	97	99 mm	7.6 g	(2,863,876) 3/	85.9
1960	61,400	10	91 mm	6.3 g	552,603	90	108 mm	10.3 g	(614,003) 4/	18.4
1961	26,038	72	92 mm	6.8 g	10,126	28	117 mm	13.1 g	(36,164) 3/	1.1
1962	1,130,820	94	82 mm	4.3 g	72,180	6	110 mm	9.9 g	1,203,000	36.1
1963	113,338	3	83 mm	4.8 g	4,116,093	97	98 mm	7.5 g	4,229,431	126.9
1964	458,122	22	87 mm	5.2 g	1,603,464	78	108 mm	9.8 g	2,061,586	61.8
1965	64,377	4	90 mm	6.8 g	1,748,178	97	109 mm	11.3 g	1,812,555	54.4
1966	252,384	92	94 mm	7.4 g	23,377	8	114 mm	12.6 g	275,761	8.3
Twelve-Year Averages	460,867	43	88 mm	5.9 g	939,039	57	110 mm	10.7 g	1,399,906	42.0

1/ One index point = 33,340 Smolt
2/ Numbers of Age I and Age II fish derived from rounded off season percentages except in 1963, 1964, 1965 and 1966 when rounded percentages were derived from numbers of smolts obtained by weighting length frequency distribution by daily catches.
3/ 24-hour index catch estimated by ratios with years of actual 24-hour fishing and from visual observations of smolt migration outside the three-hour index period.
4/ 24-hour index catch estimated from ratios with the three-hour index period catch obtained during only two days of actual 24-hour fishing.

TABLE 5

PARENT ESCAPEMENT AND CORRESPONDING RED SALMON SMOLT PRODUCTION, KVICHAK RIVER, 1952-1964

Year of Spawning	Escapement In Thousands	24-Hour Index Smolt Produced Age I	Age II	Total	24-Hour Index Smolt Per Spawner x 10^3 Age I	Age II	Total
1952	5,970		241,780			40	
1953	321	18,198	47,373	65,571	57	148	205
1954	241	30,287	8,654	38,941	126	36	162
1955	250	22,253	66,679	88,932	89	267	356
1956	9,443	3,267,274	2,777,960	6,045,234	346	294	640
1957	2,964	85,916	552,603	638,519	29	186	215
1958	535	61,400	10,126	71,526	115	19	134
1959	680	26,038	72,180	98,218	38	106	144
1960	14,630	1,130,820	4,116,093	5,246,913	77	281	359
1961	3,706	113,338	1,603,464	1,716,802	30	433	463
1962	2,581	458,122	1,748,178	2,206,300	178	677	855
1963	339	64,377	24,818	89,195	190	73	263
1964	957	252,384			262		
Averages	3,278	460,867	939,039	1,482,246	128	213	345

TABLE 6

PARENT ESCAPEMENT AND CORRESPONDING
PERCENT OF AGE II RED SALMON SMOLT PRODUCED, 1952-1964

Year	Escapement	Percent Age II Smolt Produced 1/
1952	5,970,000	10 - 15% 2/
1953	321,000	72%
1954	241,000	22%
1955	250,000	75%
1956	9,443,000	46%
1957	2,964,755	87%
1958	534,785	14%
1959	680,000	73%
1960	14,630,000	78%
1961	3,705,849	93%
1962	2,580,884	79%
1963	338,760	27%
1964	957,120	

1/ Based on 24-hour index catches.

2/ Estimated on basis of 2-ocean returns in 1956 and 5_2 fish in 1957 vs. 5_3 fish in 1957 and 6_3 fish in 1958.

APPENDIX B

Table 1. Comparative Age, Length and Index Net Catches of Red Salmon Smolt From the Wood River System, 1951-66 1/

Year of Seaward Migration	Age I 2/ Percent	Age I 2/ Mean 3/ Length	Age II 2/ Percent	Age II 2/ Mean 3/ Length	Index Points 5/ Unadjusted	Index Points 5/ Adjusted	Two-Hour Index Net Catch	Five-Hour Index Net Catch 7/
1951	80.0	91.0	20.0	--	9.9	--	16,809	8/
1952 4/	99.0	87.0	1.0	--	100.0	--	170,034	8/
1953	95.3	86.0	4.7	103.0	296.1	--	503,444	8/
1954	95.8	87.0	4.2	107.0	438.6	--	745,832	8/
1955	98.0	85.0	2.0	102.0	221.7	--	377,032	777,665
1956	78.4	82.0	21.6	95.0	329.3	326.6	559,932	1,099,782
1957	80.7	77.0	19.3	93.0	144.0	165.5	244,831	541,521
1958	65.0	82.0	35.0	102.0	249.1	230.9	423,580	868,293
1959	93.5	87.9	6.5	105.0	59.1	60.5	100,450	174,647
1960	99.4	88.0	0.6	114.0	223.3	--	379,668	8/
1961	93.0	81.7	7.0	102.1	518.7	--	881,911	8/
1962	86.0	80.1	14.0	97.6	177.6	--	301,892	8/
1963	84.3	82.6	15.7	102.1	88.9	--	151,206	8/
1964	98.8	83.7	1.2	104.2	568.6	332.2	966,807	1,318,558
1965	92.0	85.5	8.0	106.1	217.7	296.2	370,112	1,171,358
1966	94.3	77.1	5.7	101.2	147.1	133.4	250,049	527,908
Average	89.6	84.0	10.4	102.5	173.4 6/		402,724	

1/ Weighted by index catch
2/ Number winters in freshwater
3/ Mean length in mm.
4/ Base year assigned value of 100.00
5/ One index point = 1,700.34 smolt
6/ Geometric mean
7/ Five-hour index net catch obtained from following proportions:

$$\frac{\text{Two-hour Index Catch in 5-hour Sampling}}{\text{Five-hour Index Catch in 5-hour Sampling}} = \frac{\text{Seasonal Total 2-hour Index Catch}}{\text{Seasonal Total 5-hour Index Catch}}$$

8/ Five-hour sampling not available for these years

Table 2. Wood River Red Salmon Smolt Catch in Percent From the Index Net for 5-hour Period, 1955-1966

Year	Time Period				
	2100-2200	2200-2300	2300-2400	0000-0100	0100-1200
1955	23.9	18.2	25.2	20.9	11.8
1956	20.2	23.2	19.4	20.1	17.1
1957	15.3	22.1	22.0	19.8	20.8
1958	12.5	33.9	24.4	14.0	14.2
1959	15.2	26.8	20.3	24.2	13.5
1964	44.1	29.2	8.0	7.0	11.7
1965	10.6	21.0	29.8	17.3	21.3
1966	12.8	34.6	28.2	13.4	11.0
Arithmetic Mean	19.3	26.1	22.2	17.1	15.2

Table 3. Average Length and Weight of Wood River Red Salmon Smolts by Freshwater Age Group, 1961-66 1/

Year of Seaward Migration	Age I		Age II	
	Length	Weight	Length	Weight
1961	81.7	4.3	102.1	7.7
1962	80.1	4.2	97.6	7.9
1963	82.6	5.1	102.1	9.3
1964	83.7	4.8	104.2	8.5
1965	85.5	5.6	106.1	9.9
1966	77.1	4.3	101.2	7.5
Mean Average	81.8	4.7	102.2	8.5

1/ Weighted by index net catch

Table 4. Percentage of Wood River Red Salmon Smolt Parasitized by the Cestode, Triaenophorus crassus, 1961-66

Year	Total Number of Smolt Examined	Number of 1 lb. Samples Examined	Range of 1 lb. Samples Size	Percent Smolt Parasitized All Samples	Range Between Samples in Percent Parasitized
1961	5,467	60	59-129	11.9 1/	0-27.3
1962	4,789	58	47-125	22.8	2.4-46.2
1963	4,091	55	44-99	26.9	0-61.7
1964	5,984	68	64-118	54.4	29.7-84.1
1965	4,809	60	50-109	29.2	12.8-50.8
1966	5,516	53	54-166	22.5	4.4-57.5
Mean Average	5,109	59	53-124	25.2 2/	8.2-54.6

1/ Parasitized smolt were not counted during first week of seaward migration when percentage is highest. Consequently, percent parasitized all samples is a low estimate.

2/ Geometric mean.

Table 5. Wood River Red Salmon
Escapements and Smolts Produced, 1951-64

Year	Wood River Escapement	Index Values of Smolts Produced		Total	Index Units Per 1,000 Spawners
		Age I	Age II		
1951	458,000	282.2	18.4	300.6	.66
1952	227,000	420.2	4.4	424.6	1.87
1953	516,000	217.3	71.1	288.4	.56
1954	571,000	258.2	27.8	286.0	.50
1955	1,383,000	116.2	87.2	203.4	.15
1956	773,000	161.9	3.8	165.7	.21
1957	289,000	55.3	1.3	56.6	.20
1958	960,000	222.0	36.3	258.3	.27
1959	2,209,000	482.4	24.9	507.3	.23
1960	1,016,000	152.7	13.9	166.6	.16
1961	461,000	74.9	6.8	81.7	.18
1962	874,000	561.8	17.4	579.2	.66
1963	721,000	200.3	8.4	208.7	.29
1964	1,076,000	138.7	1/		

1/ The Age II smolts from the 1964 escapement will not leave freshwater until 1967.